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In order to explain the case reported by Whitman an entirely new and unsupported behavior of the lethal factor is hypothesized. This consists in a supposition that females possessing two doses of the lethal die. Inasmuch as a female with two doses of a sex-linked lethal could not be formed except by mutation, provided the relations observed in *Drosophila* hold true, the presence of a sex-linked lethal factor of the accepted type does not appear to be strongly supported. In the case of the rats a simple statement of a difference in reciprocal crosses is the sole evidence. In this case no lethal action is apparently involved; but sex-linkage might possibly account for the result. Until actual experimental evidence on this matter is available, however, it seems as though it was not sufficiently definite to be considered as having previously established the existence of sex-linkage in rodents.

C. C. LITTLE

CONCERNING THE FOSSILIZATION OF BLOOD CORPUSCLES

RECENTLY, while studying a series of microscopic preparations of fossil material in connection with paleopathology, I observed in sections of a dinosaur bone (possibly *Apatosaurus*) which I had collected in the Como beds of Wyoming in 1906, some ovoid bodies, arranged around the periphery of vascular spaces and Haversian canals, which looked remarkably like blood corpuscles. Close scrutiny of the available material, however, did not satisfy me that the objects might not be the products or by-products of incomplete crystallization. The majority of the bodies had the size and shape of modern reptilian erythrocytes; the nucleus of course not being evident, since only the outward form of the corpuscle was to be seen. Other bodies, apparently similar, were irregular in shape and hard to distinguish structurally from the regular bodies. These latter, however, may be masses composed of several corpuscles which had become agglutinated.

Not being satisfied with the results of my observations, I should not have published anything about it had I not seen in a memoir by Seitz¹ a description of similar bodies in sections of normal

¹ Adolf Leo Ludwig Seitz, 1907, "Vergleichenden Studien über den mikroskopischen Knochenbau fossiler und rezentner Reptilien und dessen Bedeutung für das Wachstum und Umbildung des Knochengewebes im allgemeinen," *Nova Acta. Abh. der Kaiserl. Leop.-Carol. Deutschen Akad. der Naturforscher. Halle*, Bd. LXXXVII, No. 2, 329-330, Tab. XXI, Fig. 61, where the corpuscles are shown in a photomicrograph in 365 diameters.

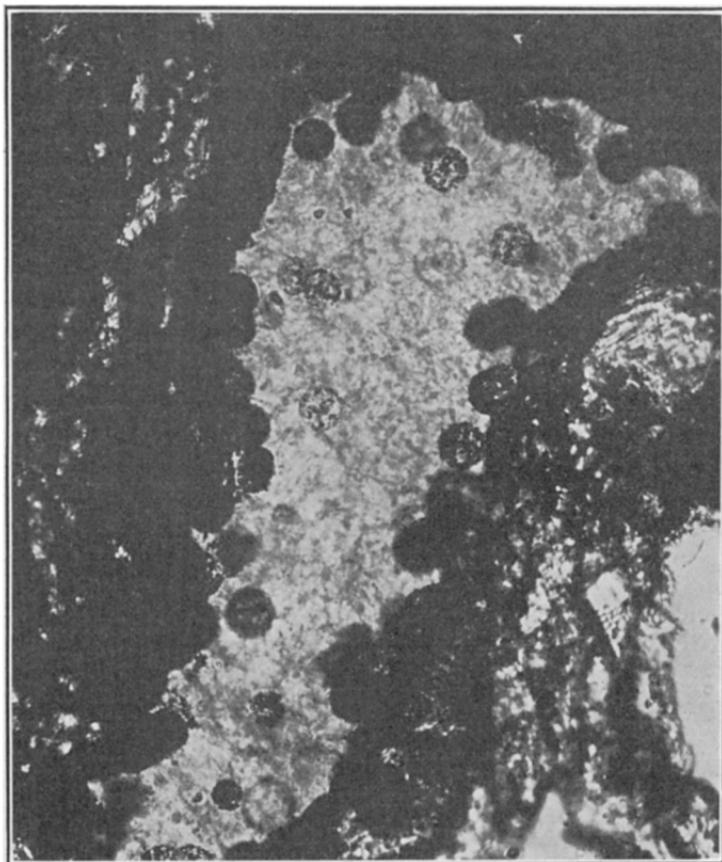


FIG. 1. A vascular space in a normal metatarsal of *Apatosaurus*, or some related dinosaur, from the Como Beds of Wyoming, showing in the rounded marginal bodies, the preservation of supposed blood corpuscles. Magnified 200 diameters. These are the same bodies that Seitz saw in European dinosaurs. The light area is the vascular space filled with clear quartz. The dark marginal areas are osseous trabeculae rendered dark by iron. The sharp indentations in the border of the vascular space are interpreted by Seitz as Howship's lacunæ, in which case the rounded bodies would be osteoclasts and not blood corpuscles. Renault searched for, but failed to find, blood corpuscles in bone from the Permian of the Autun basin of France.

bone from the European dinosaur, *Iguanodon Bernissaertensis* from the Wealden of Bernissaert, Belgium. Seitz's description of the blood corpuscles follows:

A larger part of the Haversian canals of *Iguanodon* is empty. A part of them, however, contain small, round, biconvex bodies, apparently with flat surfaces, which occur regularly or scattered about in the lumen of the vessels, with an occasional one near the periphery. Not seldom a compact mass of them entirely fills the blood-vessel. Professor Solereder of Erlangen declares that the bodies are not of plant origin

(spores), and by polarization it is determined that the bodies resemble somewhat crystalline concretions, so that we are forced to the conclusion that we have here some fossilized blood corpuscles. The partial filling of the blood vessel may be due to coagulation or a peripheral thrombus. There is also to be found frequent accumulations of reddish crystals which resemble hæmatoid crystals, and which support the suggestion as to the nature of the material. I give these observations with some reservation.

We may gain an insight into the possibility of the fossilization of blood corpuscles by studying the results of the researches into the nature of the mummified brain material of the ancient Egyptians. This subject has been studied by Mair,² who finds that the lipoids of the brain from Coptic bodies, 500 B.C., had been changed into cholesteryl stearate and palmitate.³ Mair obtained cholesteryl stearate by heating cholesterol with stearic acid, and one may infer that the heat of the desert sands in which the bodies were buried may have been an important factor in the conversion of the brain lipoids into the two relatively resistant substances, palmitate and cholesteryl stearate. These brains, even those dating from a period prior to the process of embalming (4500 B.C.), are frequently so well preserved, though greatly shrunken, that practically all the gyri may be accurately determined. This item from more recent times may aid in an explanation of processes occurring in geological ages.

The studies on Egyptian mummies have not resulted in the discovery of blood corpuscles. Schmidt⁴ examined bodies dating from 1000 years before Menes (3400 B.C.) to 500 B.C. (mummified material from Coptic bodies) and was unable to find a positive hæmin reaction, tending to show the complete disappearance of all blood in the process of time. Wood Jones,⁵ however, is convinced that traces of blood are readily discernible. Elliot Smith has referred to blood stains on bandages used in

² W. Mair, 1913, "On the Lipoids of Ancient Egyptian Brains," *J. Path. and Bacteriol.*, XVIII, 179-184; 188.

³ Mair's results are confirmed and extended by Lapworth and Royle, 1914, "The Lipoids of Ancient Egyptian Brains and the Nature of Cholesteryl Esters, *J. Path and Bacteriol.*, XIX, 474-477.

⁴ W. A. Schmidt, 1907, "Chemische und biologische Untersuchungen von ägyptischen Mumienmaterial, nebst Betrachtungen über das Einbalsamierungsverfahren der alten Aegypter," *Ztschr. f. allgem. Physiol.*, VII, 369-392.

⁵ F. Wood Jones, 1908, "The Post-mortem Staining of Bone Produced by the Ante-mortem Shedding of Blood," *Brit. Med. J.*, 1, 734-736.

the primitive surgery of Egypt. Ruffer in his extensive studies into the histology of Egyptian mummies did not discover any definite corpuscles.

It may be of interest to note that Friedenthal⁶ announced to the physiological society of Berlin the discovery of red blood in the body of a mammoth from eastern Siberia which had been frozen in the tundra since Pleistocene times. The precipitin reaction of the blood is similar to that of the modern elephant. No record is made of the preservation of blood corpuscles. While this is an extremely interesting discovery, it must be recalled that cold brings many chemical reactions to a halt, and there may have been little change in the blood of this mammoth during its 175,000 years of cold storage in the Siberian mud. The body had been so well frozen that the flesh was still fresh enough to satisfy the hunger of wolves and dogs.

Hoppe-Seyler has shown that dried red blood corpuscles of man contain 2.5 parts of cholesterol in 1000. While this is an extremely small amount of lipoid substance, since it is chiefly in the cortex of the corpuscle, it occurred to me that this might offer an explanation of the preservation of blood corpuscles. That is, under favorable conditions, the lipoids of the blood might be changed into some resistant substance like palmitate or cholesteryl stearate and thus retain the form of the corpuscles and delay their destruction long enough for fossilization to set in; these substances being replaced later by the mineral crystals from the magma in which the body was immersed. The beautiful little ganoid fish brains described by the writer⁷ some years ago from the Coal Measures may have been preserved in a similar way. The resemblance between brain substance and blood corpuscles is close in this respect that each has a small amount of resistant substance, a large amount of water and a relatively similar proportion of lipoids which may have become transformed, under proper conditions, into resistant substances which carried the part over the critical period of destruction.

In view of the fact that so many soft-bodied animals are so beautifully preserved in the rocks, that the histological nature of Paleozoic muscle tissue has been determined, that bacteria and the delicate parts of flowers are so frequently fossilized, it

⁶ *Deutsche Med. Wochenschrift*, 1904, p. 901.

⁷ Roy L. Moodie, 1915, "A new Fish Brain from the Coal Measures of Kansas, with a Review of other fossil Brains, *J. Comp. Neurol.*, XXV, No. 2, 135, 17 figs.

is certainly not beyond reason to expect the preservation of blood corpuscles. The subject is still an open one but this contribution to the theory of fossilization, it is hoped, may help to clear up the matter of the preservation of delicate objects.

The fossilization of any of the blood crystals as suggested by Seitz¹ is extremely improbable, since the evanescent nature of the crystals of haemoglobin is well known. Whether the crystals seen with the supposed blood corpuscles have resulted secondarily from the disintegration of haemin crystals or whether the whole appearance is due to chemical reactions in the incomplete crystallization of inorganic substances is an open question. Still we must not close our eyes to the possibility of discovery and block the way to progress by saying it is either one or the other. This paper merely opens the field.

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